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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

STANFORD MEETING, MARCH 6, 1926

The 138th regular meeting of the American Physical Society will be held at Stanford University, California, in the main lecture room of the Department of Physics, on Saturday, March 6. The first session will begin at 10 o'clock.

Titles and abstracts are given in the following pages in order of presentation.

Saturday morning at 10 o'clock; papers 1–10.

Saturday afternoon at 2 o'clock; papers 11–18, and Supplementary Program.

Other meetings of the current season are as follows:

139. April 23–24, 1926. Washington.

140. June 18, 1926. Pacific Coast Section at Mills College, Oakland, California.

D. L. WEBSTER,
Local Secretary for the Pacific Coast,
Stanford University, California.

February 20, 1926.

PROGRAM

1. Variations in Hall effect and thermoelectric power due to changes in crystallinity. L. J. NEUMAN, University of California.—Variations of the Hall constant due to changes in crystallinity have been investigated. Strain-hardening was found to produce an increase in R for Bi from -5.78 to -9.27. In Sn and Cu, however, the value of R is decreased by similar treatment. Thermoelectric effects between specimens of Fe, Al, Ni, Zn, Cu, Au, and german silver possessing different degrees of crystallinity have been measured for temperatures from 0°C to 1000°C. Thermoelectric powers of over 2 microvolts per degree C have been observed between annealed and strain-hardened specimens of a single metal. The sign of the e.m.f. is the same for all of the metals investigated. Thermoelectric effects between single capillary crystals are discussed and data given.

2. Performance of the graphic acoustic sounder during the Australian cruise of the U. S. fleet. L. P. DELSASSO, University of California, Southern Branch.—By authorization of the Bureau of Engineering of the Navy Department, the device reported at a previous meeting was installed aboard the U. S. S. Maryland. Wherever the position of the ship could be fixed accurately it was found that the record obtained with the Graphic Acoustic Sounder was in good agreement with the charted depth. The device was found to operate satisfactorily from 20 to 3500 fathoms. It is shown that the shallow limit is fixed by the oscillator characteristics, while the maximum depth may be extended by the use of filters and greater amplification.

3. Measurement of reverberation with the thermionic tube oscillator. VERN O. KNUDSEN, University of California, Southern Branch.—The writer has made reverberation measurements, using an audio-frequency oscillator and a high quality loud speaking telephone receiver instead of a series of organ pipes as has been used by W. C. Sabine and other investigators. The arrangement has the following advantages: (1) The acoustic energy generated by the receiver is proportional to the electric energy actuating the receiver, and therefore test tones of standard intensity are readily obtained from simple measurements of currents and impedances; (2) each standard test tone is based upon its tone of minimal audibility, the latter being determined by taking many measurements in different parts of the room, and therefore the reverberation measurements are almost independent of slight residual noises in a room, and do not require correction for the volume and absorption of the room; (3) the apparatus is more portable and convenient than the organ pipes with their auxiliary equipment. The apparatus has been used satisfactorily to determine the coefficients of sound absorption of many new materials used for the reduction of reverberation and noise in architectural interiors.

4. Rate of neutralization of the field in the Braun tube with external electrodes. A. M. CRAVATH and L. T. JONES, University of California.—This is a study of a problem which arose in the investigations of Jones and Tasker, J.O.S.A., **9**, 471, 1924. The field of the external electrodes is rapidly neutralized by the collection of ions and electrons on the tube walls, so that the deflection is not proportional simply to the applied voltage. The neutralization proceeds like the discharge of a condenser with time constant $RC=\tau$. This time constant τ, which is a reciprocal measure of the rate of neutralization, was calculated from current measurements made with internal electrodes, and was measured directly by photographing the variation of deflection with time, the two values for the tube used being 0.002 and 0.0013 seconds. From the latter value it is calculated that for sinusoidal voltages of 60 and 7000 cycles per second the deflection should lead the applied voltage by 65° and 1° and the amplitudes should be reduced to 40% and 99.98% of the values they would have in the absence of neutralization.

5. Phase and magnitude of deflections of Braun tube beam with internal and external electrodes. R. A. JACK and L. T. JONES, University of California.—Photo-

graphs showing a 90° phase difference between the deflections of a cathode beam of a Braun tube with 60 cycle alternating potential applied to external and internal electrodes, respectively, were published by Jones and Tasker. (J.O.S.A. **9**, 471, 1924; Phys. Rev. **23**, 777, 1924). The following work has been done to determine the phase difference at different frequencies and to determine the deflection as a function of frequency with external electrodes. At the lower frequencies the deflection is a function of the frequency, while at the higher range the deflection becomes constant. At high frequencies the deflections with external and internal electrodes are apparently equal. By the use of Lissajous' figures, with the internal and external sets of electrodes at right angles, the phase difference has been found to disappear at high frequencies. Work is being continued to complete the frequency range from 60 to several million cycles.

6. The ionization of oxygen as interpreted by positive ray analysis. T. R. HOGNESS and E. G. LUNN, University of California.—Positive-ray analysis of the products of electron-impact ionization in oxygen shows that the percentage of the ions, O_1^+ and O_2^+ is independent of the pressure of oxygen. Evidence is thus given that O_1^+ and O_2^+ are formed by independent processes, and hence that an impact electron can dissociate oxygen with the formation of the atomic ion. The ionization potentials for the formation of O_2^+ and O_1^+ were found to be 13 and 20 volts, respectively. The latter, together with Hopfield's series limit, gives 6.5 volts (150,000 calories) for the heat of dissociation of oxygen.

7. Mobilities of gas ions in HCl. LEONARD B. LOEB, University of California.—Mobility measurements were made in pure dry HCl gas using the Franck modification of the Rutherford method with an alternating potential of square wave form. The average mobility for the positive ion at 20°C and 760 mm was found to be 0.65 cm/sec per volt/cm and 0.56 cm/sec per volt/cm for the negative ion. This measurement of a negative mobility definitely less than a positive mobility constitutes the first exception to a general rule previously assumed from observation which indicated that the negative ion had a mobility either equal to or greater than the positive ion, *but not less.* The inverse pressure law of mobilities was found to hold for both positive and negative ions down to 16.3 mm pressure. It was concluded from this that the constant of attachment of electrons to HCl molecules to form negative ions was nearly as low as that for Cl_2 gas. Finally, measurements of mobilities in mixtures of air and HCl showed unmistakable signs of a cluster ion formation in this gas, the mobilities being lowered by marked amounts for fractions of a percent of HCl gas.

8. On the theory of electrolytes. F. ZWICKY, California Institute of Technology.—The theory of Arrhenius accounted for the different properties of electrolytic solutions with the hypothesis of complete or partial dissociation of the molecules of the solute, the degree of dissociation being a function of the concentration. After it had been shown, that for strong electrolytes the dissociation is complete at all concentrations, another explanation for the behavior of such solutions had to be found. Concerning the osmotic equation of state and the electrical conductivity, the problem was solved by Milner and Debye in introducing the so-called "ion-atmospheres." The ordinary equation of state (thermal and caloric), however, has not yet been treated and it is now proposed to deduce it in a general way. It appears that the effects due to the electric charges of the ions are predominant. These effects are, in outline, the following: (1) formation of ion-atmospheres; (2) electric polarization of the solvent; (3) attraction of the molecules of the solvent towards the ions with resulting high pressures (as great as 50000 atm.) in the vicinity of the ions. The mathematical treatment of these effects gives results, which are in complete agreement with the observed data of specific heat, compressibility, thermal coefficient of expansion and volume-contraction on solution.

9. The Compton effect and virtual oscillators. P. A. ROSS, Stanford University.—In recent papers by Slater and by Bohr, Kramers, and Slater an attempt has been made to reconcile quantum theory and wave theory by postulating certain "virtual oscillators"

which shall be capable of absorbing waves to synthesize quanta. If such virtual oscillators were in a region illuminated by monochromatic radiation from two sources of the same frequency it would seem reasonable that the oscillator should build up its quanta by absorbing radiation from both sources and thus acquire momentum along the resultant Poynting vector. If this absorbed quantum were passed over to an electron to be scattered according to the Compton equation, the angle of scattering and consequent change of wave-length should correspond, not to the angle between the scattered beam and either incident radiation, but to the angle between the scattered beam and the resultant Poynting vector. This was tested by placing a graphite scattering block between two x-ray tubes driven in parallel from the same transformer. Two spectrographs were set up. One received radiation scattered at 90° to both incident beams. The other received radiation at angles of 125° and 55°, respectively, from the two beams. The normal Compton effect was observed. The above theory would demand no shift.

10. The Doppler principle and the quantum hypothesis. G. E. M. JAUNCEY, Washington University.—The relativity theory demands that when an atom at rest changes from an energy state W_1 to an energy state W_2 there is a change of mass from M_1 to M_2. Hence emission of radiation is accompanied by loss of mass. Suppose an atom of mass M_1 moving with velocity $\beta_1 c$ emits a quantum in the forward direction, after which the atom has a mass M_2 and velocity $\beta_2 c$. Conservation of energy requires $M_1c^2/\sqrt{1-\beta_1^2}=h\nu+M_2c^2/\sqrt{1-\beta_2^2}$, while conservation of momentum requires $M_1\beta_1 c/\sqrt{1-\beta_1^2}=h\nu/c+M_2\beta_2 c/\sqrt{1-\beta_2^2}$. Eliminating β_2 and solving for ν, we obtain ν as a function of β_1. Now calling ν_0 the value of ν when $\beta_1=0$, we obtain $\nu/\nu_0=(1+\beta_1)/\sqrt{1-\beta_1^2}$. If β_1 is small and we put $\beta_1 c=v$, then $\nu/\nu_0=(c+v)/c$. The formula for the Doppler principle has thus been obtained without the use of the classical wave-theory.

11. The crystal structure of $[N(CH_3)_4]_2PtCl_6$. MAURICE L. HUGGINS, Stanford University.—Using Laue and spectrum photographs and the theory of space groups, the structure of tetramethyl-ammonium chloroplatinate has been determined. The structure has cubic symmetry, with $a_0=12.65$A. Pt and N atoms are disposed as are the Ca and F atoms in CaF_2 (special cases 4*b* and 8*e* in Wyckoff's "The Analytical Expression of the Results of the Theory of Space-Groups"). Each Pt is surrounded by 6 Cl atoms (24*a*) at corners of a regular octahedron, and each N is surrounded by four C atoms (32*a*) at corners of a regular tetrahedron. The symmetry is that of the space-group $O_h^5(Oi-5)$ or that of $O^3(O-3)$. Assuming the N–C distance to be 1.47A, the best agreement with the data is obtained when Pt–Cl is taken as about 2.35A. This research was done while the author was National Research Fellow in Chemistry at the California Institute of Technology.

12. Series due to halogens in infra-red absorption spectra of organic compounds. JOSEPH W. ELLIS, University of California, Southern Branch.—Absorption band series, attributed to carbon-hydrogen and carbon-carbon bonds have previously been reported by the writer. The absorption spectra of methylene chloride and chloroform contain, in addition to the C-H series, bands which fit a linear, or "harmonic," series whose initial wave-length member seems to be 16.8μ. The remaining bands of the short wave-length spectra can readily be accounted for by combinations between this series and the C-H series. Similarly, bands in the spectra of methylene bromide and bromoform, and methyl iodide and methylene iodide, can be grouped into linear series, which start at 17.2μ and 17.5μ, respectively. Members of combination series can also be identified in these latter spectra. Members of these series can also be found in spectra of more complicated molecules containing halogen atoms, but the spectra are complicated by the presence of bands due to C-C pairs. That these bands are due to the presence of halogen atoms seems certain; that the presence of hydrogen in the molecule is necessary for their appearance seems also certain, as carbon tetrachloride and tetrachlorethylene, containing only carbon and chlorine atoms, show no absorption in the short wave infra-red region.

13. On the specific heat of hydrogen. G. H. DIEKE, University of California.—A recalculation of the specific heat of hydrogen has been made on the basis of the new development in band spectra. The *probabilities a priori* have to be of the form $p_j = j + a$, where a can be left undetermined. (j is the total moment of momentum of the molecule.) The results are: (a) m (rotational quantum number) $= \frac{1}{2}, 1\frac{1}{2}, 2\frac{1}{2}, \ldots$. Only moderate agreement between theory and observations for any choice of the p_j; (b) $m = 1\frac{1}{2}, 2\frac{1}{2}, 3\frac{1}{2}, \ldots$. (suggested by the visible H_2 bands (Fulcher bands)). Dieke, Proc. Amsterdam, **27**, 490. See also Hutchisson and Van Vleck, Phys. Rev. **25**, 243 gives much better results with the p_j to be expected by theory; (c) $m = j \pm \frac{1}{2}$, which is suggested by the alternating intensities in the Fulcher bands gives also good agreement for low temperatures. Other assumptions, less probable, also give curves which agree fairly well at low temperatures. The present measurements are not sufficient to decide in favor of one particular hypothesis. For higher temperatures the non-rigidity of the molecule would change the curves considerably. There are, however, no data as yet which would allow with any certainty the calculation of the curves for a non-rigid molecule.

14. New oxygen bands between 2000–2300. VIVIAN M. ELLSWORTH and J. J. HOPFIELD, University of California.—Sixteen new bands due to ionized oxygen have been photographed in the region 2000–2300. They occur in pairs degraded to the red. The pairs have a constant frequency difference of 200 units. The bands appear to be an extension to the ultra-violet of the group of electronic O_2^+ bands arranged in Deslandres progressions by Johnson. Mecke has made quantum assignments of the group. The progression having the lowest final state according to his interpretation, is now extended by two members having higher initial states than those previously reported. The total number of initial states now indicated is ten. A new progression having a still lower final state appears and fits the scheme. This necessitates raising the previously assigned quantum numbers for the final states by at least one unit. Other bands which are too dim to measure but which have the characteristic appearance of the group and may belong to it, appear farther to the ultra-violet. The O,O band and those in its neighborhood are still missing and the general character of the schematic arrangement is unchanged by the additions.

15. On the absorption bands of nitric oxide. H. SPONER and J. J. HOPFIELD, University of California.—It was recently shown by one of us that the final state of the third positive group of nitrogen (γ bands) is the stable state of NO. Now it was found from absorption plates in NO taken by Dr. Leifson and kindly sent to us, that also the β bands occur on these plates proving that the β and the third group bands have a common final state as was suggested by Mulliken and by Birge. This progression from the normal state extends the scheme of the β bands from $n'' = 3$ (final) to $n'' = 0$. According to a suggestion by Mulliken, the stable state is a double p level corresponding to aluminum, while the initial state of the third positive group bands corresponds to an s level and that of the β bands to a double d level.

16. The fine structure of the λ4842 band of AlO. WILLIAM C. POMEROY, University of California.—The rotational energy of the AlO molecule has been represented by $F = Bm^2 + Dm^4 + Fm^6 + Hm^8$ where $m = k - \epsilon$. K is a half integer representing the resultant molecular momentum. Approximate values of ϵ are .0074 and .01 for the initial and final states respectively. Vibrational frequencies for infinitesimal vibration calculated from Kemble's formula, $\omega = \sqrt{-4B^3/D}$, agree with values obtained from vibration data alone within 0.2%. The doublet separation of band lines was represented as a function of m of the initial state for both the P and R branches by a single equation, $\Delta\nu = .0116m + 12 \times 10^{-6}m^2 - 7 \times 10^{-11}m^6$. Attributing the doublets to a double energy level in the initial state $(F')^{+-} = \pm .0058m + (.6019 \pm 6 \times 10^{-6})m^2 - (1.1630 \pm 3.5 \times 10^{-11})m^4 + .54 \times 10^{-12}m^6$; $(F'') = .6386m^2 - 1.1094 \times 10^{-6}m^4 - .43 \times 10^{-12}m^6 - 5.2 \times 10^{-8}m^8$. Throughout the measured range ($k = 140.5$), observed frequencies of lines of the (O,O) band agree with those calculated from $P_k^{+-} = 20635.27 + (F'_{k-1})^{+-} - F_k''$; $R_k^{+-} = 20635.27 + (F'_{k-1})^{+-} - F_k''$ with residuals rarely exceeding .04 cm^{-1} (.01A).

17. Theory of intensity distribution in band systems. EDWARD CONDON, University of California.—Franck (Trans. Faraday Soc. 1925) has given a simple mechanical explanation for the large change in vibration quantum number in the absorption bands of cold (non-vibrating) iodine molecules. It is assumed that the electron transition affects only the binding of the atoms, leaving unaltered the relative nuclear separation. Quantitative treatment of this model by the author embodies the application to transitions where the molecule is vibrating in the initial state and assumes further that the nuclear velocities are not changed by the electron transition, explaining thereby the major aspects of the observed intensity distributions in band systems in emission and absorption. The theoretical expression is: $n''=\pi\omega''md^2/h+\frac{1}{2}(\omega'/\omega''+\omega''/\omega')n'-\sqrt{n'}\sqrt{4\omega''/\omega'(\pi\omega''md^2/h)}\sin\theta+\frac{1}{2}(\omega'/\omega''-\omega''/\omega')n'\cos 2\theta$. Here n'' and n' are the final and initial vibration quantum numbers, ω'' and ω' the final and initial vibration frequencies, m the reduced mass, d the difference in equilibrium separation in the two electronic states and θ the phase of the vibration at the instant of electron transition. Applied to the meager experimental data for emission bands of AlO, CO, CO^+, N_2 (2nd pos. group), N_2^+ (1st neg. group), SiN and I_2 the theory is in good accord with the facts.

18. The heat of dissociation of non-polar molecules, as determined from band spectra, and from other sources. RAYMOND T. BIRGE and HERTHA SPONER, University of California.—The limiting amount of vibrational energy which a diatomic molecule can possess is given by $E_n=h\int_0^{n_0}\omega^n dn$, where ω^n is the frequency of vibration, as a function of the vibrational quantum number n, and n_0 is the value of n for $\omega^n=0$. For *non-polar* molecules n_0 is finite, for polar molecules it is infinite. Usually the ω^n:n curve for the stable molecular state is strictly linear, over the known range, and its linear extrapolation to $\omega^n=0$, *for essentially non-polar molecules*, seems to give the true value of E_n to within half a volt. Since the molecule dissociates into two stable atoms, $E_n=Q$, the heat of dissociation. When the molecule dissociates, while excited by E_e units of electronic energy, the products of dissociation seem from previous work on iodine to be one stable and one excited atom (of excitation energy A). Hence $Q+A=E_e+E_n$. For dissociation from certain excited states of O_2, CO, and NO, A seems to be negligible (see following abstracts). Values of Q have thus been obtained for O_2, O_2^+, N_2, N_2^+, CO, CO^+, and NO. These values are self-consistent and are also consistent with data from other sources.

19. The heat of dissociation of O_2 and O_2^+. RAYMOND T. BIRGE, University of California.—Using new data by Hopfield and Leifson, the ω^n:n curve for the excited state of the Schumann bands of oxygen is known almost to $\omega^n=0$. The true value of E_n (see preceding abstract) is thus known to ± 0.01 volt. $E_e+E_n(=Q+A)=7.05$ volts, and A is probably only 0.01 or 0.03 volts. (The stable state of oxygen atom is a triple p level, of 0.01 and 0.02 volts spacing.) Hence the true heat of dissociation of O_2 is 7.05 ± 0.03 volts. Mulliken finds that the Runge bands are a portion of the above system, and the new data thus available for the stable state of O_2 yield an apparently linear ω^n:n curve from $n=0$ to 17. Its linear extrapolation (to $n_0=69$) gives $E_n=Q=6.66$ volts, showing the probable error (± 0.5 volts) of such an extrapolation. The O_2^+ band give $Q'=6.24$ volts, from a linear ω^n:n curve for the stable state, and 6.31 volts from a linear excited state curve, ($O_2^+ + Q'$ volts $= O+O^+$). I' (ionization potential of atom) $=13.5$ volts. Therefore I (ionization potential of molecule) $=14.3$ volts, since from conservation of energy, $I+Q'=Q+I'$, always. These values agree with the Hogness and Lunn results of positive ray analysis of oxygen.

20. The heat of dissociation of N_2 and N_2^+. HERTHA SPONER, University of California.—Q for N_2 has been suggested by the writer as about 11.4 volts, from the energy of active nitrogen. The ω^n data for the stable state are unknown. The ω^n:n curve for the final state of the first positive group gives $E_e+E_n=8.0+3.87=11.87$ volts. Because of the non-linear character of the curve, this result is only approximate. The above value

is supported by the results of Hogness and Lunn, who get M^+ ions at 24 volts as the result of a collision of an excited N_2 with a neutral molecule. The explanation can be given by the process $N_2^{exc}(24) \rightarrow N + N^+(13) + Q(11.4)$. The value for ionization of N(=13) is estimated roughly from spectroscopic data. For N_2^+ one obtains 9.06 volts for Q' from a linear graph for the final state, and 9.7 volts from the linear extrapolation of an actual negatively curved $\omega^n:n$ graph. Hence this last result should be too large. Using the $I+Q'=Q+I'$ equation with the known $I=16.5$ volts, $16.5+9.06=11.4+I'$. This gives $I'=14.16$ volts, to be compared with the above 13 volts. The agreement is within the limits of error.

21. The heat of dissociation of CO, CO^+, and NO. RAYMOND T. BIRGE and HERTHA SPONER, University of California.—A strictly linear $\omega^n:n$ curve for the stable state of CO (known to $n=22$) gives $Q=11.18$ volts. The next higher electronic level gives $Q=12$ volts, but is more uncertain. The third level is unsuitable for this work. The heat of sublimation of diamond (6.11 volts) and other known chemical data, combined with the now known value $Q=7.05$ volts for O_2, give $Q=10.78$ volts for CO, a probably better value than 11.18. Only the stable state of CO^+ gives a linear $\omega^n:n$ curve and the resulting $Q'=9.82$ volts, ($CO^+ + Q'$ volts $= C + O^+$ assumed). The known I for CO is 14.2 volts, and I' (of oxygen atom) is 13.5 volts. Hence $I+Q'=Q+I'$ becomes $14.2+9.82=10.78+13.5$, a satisfactory agreement. For NO only the excited state of the gamma bands gives a linear $\omega^n:n$ curve. The resulting $E_e+E_n=17.19$ volts. Assuming $Q=7.05$ for O_2 and 11.4 for N_2, and knowing $N_2+O_2+1.9$ volts $=2$ NO, $Q=8.27$ volts for NO. Since $E_e+E_n=Q+A$, A equals 8.92 volts, and this type of dissociation of NO seemingly results in a neutral nitrogen and an 8.9 volt excited oxygen atom, agreeing with the known resonance potential of oxygen (9.1 volts).

22. The crystal structures of anatase and rutile, the tetragonal forms of TiO_2. MAURICE L. HUGGINS, Stanford University.—Using Laue and spectrum photographs and the theory of space-groups, the structure obtained by Vegard for anatase and that obtained by Vegard and by Greenwood for rutile have been verified. The unit cell of anatase has the dimensions $a_0=3.78$A and $c_0=9.50$A; it contains Ti atoms at (000) $(0,\frac{1}{2},1,\frac{1}{4})(\frac{1}{2},0,\frac{3}{4})(\frac{1}{2},\frac{1}{2},\frac{1}{2})$ and O atoms at $(00u)(0,\frac{1}{2},u+\frac{1}{4})(\frac{1}{2},0,u+\frac{3}{4})(\frac{1}{2},\frac{1}{2},u+\frac{1}{2})(00u)(0,\frac{1}{2},\frac{1}{4}-u)$ $(\frac{1}{2},0,\frac{3}{4}-u)(\frac{1}{2},\frac{1}{2},\frac{1}{2}-u)$ where $u=.20\pm.01$. The symmetry of this arrangement is that of the space group $D_{4h}^{19}(4Di-19)$. For rutile $a_0=4.58$A and $c_0=2.95$A, Ti atoms are in the positions $(000)(\frac{1}{2},\frac{1}{2},\frac{1}{2})$ and O in $(uuo)(uuo)(\frac{1}{2}-u,u+\frac{1}{2},\frac{1}{2})(u+\frac{1}{2},\frac{1}{2}-u,\frac{1}{2})$, where $u=.30$ $\pm.01$. The symmetry is that of $D_{4h}^{14}(4\ Di-14)$. This research was done while the author was National Research Fellow in Chemistry at the California Institute of Technology.

23. PP′ groups in the elements S(I) to K(IV). J. J. HOPFIELD and G. H. DIEKE, University of California.—Two new PP' multiplets representing double electronic transitions in A (III) and K (IV) have been added to those already observed (Hopfield, Phys. Rev. **23**, 766 and **26**, 282). The final state of these four groups is the lowest P level, which is also the valence level. The six lines of these multiplets are clearly resolved on our spectrograms of S, Cl and A. The position of the multiplet in K(IV) was predicted and then found among Millikan and Bowen's data. The wave numbers of the multiplets are: S (I), 72380, 72174, 72019, 71985, 71805, 71625; Cl (II), 93995, 93626, 93357, 93305, 92995, 92669; A(III), 114797, 114216, 113803, 113687, 113228, 112690; K (IV), 135691, 134745, 134174, 133326, 132222. Bowen and Millikan (Phys. Rev. **26**, 150) have also observed PP' groups in a series of elements. A comparison of this work with their's shows (1) that the structures of the groups are alike except that in the present case the triple levels are inverted, (2) that the successive frequency differences of the groups S (I) to K (IV) are nearly equal to those of Mg (I) to Cl (VI), (3) that the difference in frequency between the S (I) and the S (V) multiplets is approximately equal to the separation of the Cl (II) and the Cl (VI) groups. This multiplet has not been found in O (I).